Containment vs. Confinement

ISSUE 6: Under what conditions can a plant be licensed without a pressure-retaining containment building (i.e., a confinement building instead of a containment)?

BACKGROUND:

In SECY-93-092, "Issues Pertaining to the Advanced Reactor (PRISM, MHTGR and PIUS) and CANDU 3 Designs and Their Relationship to Current Regulatory Requirements," April 8, 1993, the staff described the containment and confinement concepts for the reactor designs under consideration. In the case of the Modular High-Temperature Gas-Cooled Reactor (MHTGR), a confinement concept (negative pressure building with filtered exhaust, but no pressure-retaining capability) was proposed. This same concept has been incorporated into the pebble bed modular reactor (PBMR) and gas-turbine modular helium reactor (GT-MHR) designs, thus again raising this issue for Commission consideration. With a confinement building, large leaks from the primary coolant system would cause the confinement building to initially vent (unfiltered) to the atmosphere until the pressure was relieved and then either continue to relieve any additional pressure buildup (unfiltered) or resume negative pressure filtered operation for the duration of the accident, unless electric power was lost, in which case slow unfiltered leakage from the building would occur. In addition to filtering, fission product attenuation in the reactor or by other building structures can also retain fission products. A confinement building was used on Fort St. Vrain and many gas-cooled reactors in other countries. For HTGRs, the long core heatup time and the fission product retention capability of the fuel are considered by the designers to be sufficiently robust to make a conventional pressure-retaining containment unnecessary and possibly detrimental to the passive decay heat removal systems proposed.

In SECY-93-092 the staff addressed the MHTGR confinement concept and proposed functional performance criteria to evaluate the acceptability of proposed designs, rather than to rely exclusively on prescriptive containment design criteria. The proposed criteria were based upon ensuring that building performance is consistent with accident evaluation criteria. Specifically, the staff proposed that:

- Designs were to be adequate to meet the specified onsite and offsite radionuclide release limits for the event categories within their design envelope.

- For a period of approximately 24 hours following the onset of core damage,[1] the specified containment challenge event was to result in no greater than the limiting leak rate used in evaluation of the event categories, and structural stresses were to be maintained within acceptable limits (i.e., ASME level C requirements or equivalent). After this period, the uncontrolled release of radioactivity must be prevented.

In response to SECY-93-092, the Commission issued a staff requirements memorandum (SRM) on July 30, 1993, which approved the staff's recommendation. In addition, the Commission went on to state that "for the MHTGR, the staff should also address the following type of event. The loss of primary coolant pressure boundary integrity whereby air ingress

[1] A core damage accident was to be postulated as a containment challenge event.

could occur (from the “chimney effect”) resulting in a graphite fire and the subsequent loss of integrity of the fuel particle coatings.”

DISCUSSION:

The use of a pressure-retaining containment building has been considered a key element of the basic design as well as a significant element of defense-in-depth for LWRs. It has been a traditional way to protect against unknowns or uncertainties that could lead to core damage and the uncontrolled release of large quantities of radioactive material. It is an especially important feature if extensive core damage can occur and result in the release of large quantities of radioactive material. It should be emphasized that the presence of a traditional containment building has been useful in protecting public health and safety (e.g., TMI-2) and has been emphasized as an important plant feature which can enhance public confidence. However, certain reactor designs may have a long delay before the release of large amounts of radioactive material or may preclude extensive core damage altogether. In such cases it is reasonable to consider whether or not a traditional pressure-retaining containment building is necessary or is the most effective way to protect public health and safety. In addition, physical protection of the reactor and critical systems, structures and components from external threats can be accomplished with non-pressure-retaining structures. Key considerations regarding the need for a pressure-retaining containment building include:

- Would the addition of such a feature substantially improve safety?

- Does the reactor design preclude or significantly delay core damage?

- Is there sufficient confidence in the reactor design such that a pressure-retaining containment is not needed to cover uncertainties?

- Is there sufficient confidence in the reactor design to eliminate from consideration severe core damage and the release of large quantities of fission products?

- Can criteria be developed that, if met, would provide sufficient confidence that a pressure-retaining containment is not needed?

At the public workshop held on October 22–23, 2002, there was no general consensus among participants regarding the need for a pressure-retaining containment building or the use of the criteria defined in SECY-93-092. Some participants felt a conventional approach to containment was necessary to account for uncertainties and to ensure public confidence, while others felt it could detract from safety, particularly for HTGRs, as well as impose a large unnecessary capital and operational cost.

OPTIONS :

The options considered by the staff in addressing this issue are:

(a) Require all future reactors include in their design a low leakage containment building capable of retaining pressure.

This option would clearly establish traditional containment as a key element of defense-in-depth and provide a degree of protection against uncertainties in a plant's ability to prevent severe core damage, for example through the entrance of air into a hot HTGR core. This option would also reduce concern over uncertainties in fuel performance and fission product release over a wide range of accident scenarios as well as reduce any concern about a loss in fuel quality due to fabrication problems over the life of the plant. In addition, it would likely tend to have a positive effect on public confidence. However, this option could reduce the incentive for designers to emphasize accident and fuel damage prevention in their designs. Also, the addition of a traditional containment would add cost that may not be commensurate with the safety benefit. In fact, some have argued that the addition of a traditional containment building will have a negative impact on safety by reducing the reliability of decay heat removal systems (which in many designs are to be passive) and by causing the retention of hot, pressurized non-condensable gas in the building following a loss of coolant accident, thus providing a driving force for any fission products that might ultimately be released from the core during the course of the accident. Finally, this option is not consistent with the position taken in the Commission's July 30, 1993, SRM.

(b) Allow a plant to be licensed without a containment building capable of retaining pressure, provided certain performance criteria are met.

This option would build upon the Commission's July 30, 1993, SRM, which approved the licensing of a design without a building capable of retaining pressure provided certain plant performance criteria could be met. These criteria were defined in SECY-93-092 (as discussed above). However, this option is limited to the fundamental issue of whether a plant can be licensed without a pressure retaining containment building. In view of the progress made since 1993 on risk-informed and performance-based regulation and the recommendations on the other issues in this paper, it may be appropriate to revisit the 1993 criteria after Commission guidance is received on the issues in this paper. Revisiting the 1993 criteria could be done as part of developing a policy or description of defense-in-depth, if approved by the Commission, or as part of developing a framework for future plant licensing.

This option would provide flexibility and incentive for designers to emphasize accident prevention and the prevention of core damage. As such, this option could improve safety if it results in designs with enhanced prevention characteristics. However, this option places emphasis on ensuring there is sufficient understanding of fuel and plant performance and uncertainties over a wide range of conditions and that the fuel fabrication process maintains fuel quality over the life of the plant. Therefore, in the absence of operating experience for new designs, this option would require robust research and development to confirm plant and fuel performance and to characterize uncertainties. This option may not, however, have a positive effect on public confidence.

RECOMMENDATION:

The staff recommends the Commission take the following action:

- Approve the use of functional performance requirements to establish the acceptability of a containment or confinement structure (i.e., a non-pressure retaining building may be acceptable provided the performance requirements can be met).

- If approved by the Commission, develop the functional performance requirements using as a starting point the guidance contained in the Commission's July 30, 1993, SRM and the Commission's guidance on the other issues contained in this paper.

This recommendation is consistent with Option b above and is coupled to the recommendations on Issues 4 and 5 discussed in Attachments 4 and 5, respectively. Similar to those recommendations it would represent a risk-informed and performance-based method to account for the unique aspects of each reactor design. In addition, resolution of this issue will establish a key element for incorporation into any policy or description of defense-in-depth.

If approved by the Commission, this recommendation could also permit a hybrid containment design, whereby pressure is vented early in the accident sequence and then a low leakage pressure-retaining configuration is established for the long term.